HYDROLOGY

PRECIPITATION

Average annual precipitation in the upper subbasin (Farmington, Missouri weather station) is 40.5 inches, with 18.5 inches of annual runoff (NRCS 1981). The average annual precipitation in the lower subbasin (Kennett, Missouri, weather station) is 49.5 inches, with 22.0 inches of annual runoff (NRCS 1979). The nine inches of additional rainfall in the lower subbasin occurs during the cooler months. Average spring air temperature is about 5°F warmer and the growing season is 35 days longer in the lower subbasin.

GAGING STATIONS

The USGS is responsible for recording flows in the upper subbasin and the United States Army Corps of Engineers (USCOE), Memphis District, records mainstem flows in the lower subbasin. The USGS currently operates four mainstem gages, two tributary gages, a lake-stage recorder at the dam, and another mainstem gage immediately below the dam (Table 1). The USCOE operates eight stage recorders on the mainstem of the river below the dam (Table 1). There are no USCOE gaging stations on tributaries in the lower subbasin.

USGS gage information is recorded and published by water year (October 1 through September 30), and includes long-term averages (period of record) and summary statistics that include low flow information. USCOE gage information, available by request, is recorded by calendar year and does not include long-term averages and summary statistics related to low flows because of the regulated flow exiting Wappapello Dam.

STREAMFLOW CHARACTERISTICS (UPPER SUBBASIN)

Streamflow characteristics are listed in Table 2. Peak discharges usually occur in November and December, and again during April. February stream flows generally equal the mean annual discharge at each gage site. Discharge typically recedes sharply during June, and base flows are reached by early July and continue through October.

Periods of peak discharge do not correspond with periods of greatest precipitation. Early winter peak discharges, with about 3.3 inches of monthly precipitation, are slightly higher than spring discharges, with about 4.6 inches of monthly precipitation. The highest floods and maximum recorded discharges, at all gage sites, have occurred during the winter months. Winter watershed conditions are probably responsible for increased runoff during winter storm events. Less evapotranspiration (cool air temperatures), less ground cover (annual plants), a naked forest canopy (raindrop interception), saturated soils (some snow), or frozen soils are all factors that can contribute to increased winter runoff.

The predominance of impervious rock in the upper basin limits infiltration, fracturing, and subsurface flows, causing rapid runoff which produces flashy hydrographs and frequent flooding.

The result is a poor aquifer that provides low, unstable base flows with few springs. High gradient, fourth and fifth order tributaries on the west slope of the mainstem (Stouts Creek, Marble Creek) and lower gradient, fifth order tributaries on the east slope (Little St. Francis River, Wolf Creek) can become intermittent during periods of drought.

Groundwater supply, storage, and movement steadily improve in a downstream direction as the shallow igneous bedrock in the headwaters is eventually replaced by deeper water-soluble dolomites near Wappapello Lake. Higher and less variable mainstem base flows are evident at downstream gage sites. However, even at the Patterson gage, which is only five miles above Wappapello Lake, low-flow stability is considerably less than the neighboring Black River and Castor River basins. Wappapello Lake rests on a much younger, water-soluble Gasconade dolomite that allows considerable groundwater movement (MDNR 1986a). Some small tributary streams that now drain directly into the lake (*e.g.* Otter Creek, Happy Hollow Creek) are losing streams that emerge as springs on the lake bottom (*e.g.* Blue Springs).

Exceptions to the subbasin's seasonal low flow are Big Creek (fifth order) and its major tributary, Crane Pond Creek (fourth order). The geology of the Big Creek watershed is not greatly influenced by the St. Francois Mountains uplift, but, instead, is more closely related to the deep, cherty limestone residuum of the upper Black River basin. The unconsolidated alluvium throughout the watershed provides subsurface storage and allows rapid groundwater movement that sustains and stabilizes base flows.

It appears that the magnitude of floods is more related to average hydraulic gradient than watershed area. For example, the Little St. Francis River has the second largest area, but the lowest gradient. Several smaller streams had similar, or greater magnitude floods. Cedar Bottom and Wachita creeks have small watershed areas, but steeper gradients and had flood magnitudes similar to larger streams.

STREAMFLOW CHARACTERISTICS (LOWER SUBBASIN)

Flow in the lower St. Francis River is primarily regulated by water released through Wappapello Dam. However, extensive infiltration produces a good aquifer with abundant groundwater supplies, high base flows, and a water table high enough to maintain standing water in large drainage ditches during prolonged dry periods. The high water table can also cause major agriculture problems.

Flood flows (typically exceeding 25,000 cubic feet per second (cfs)) in the upper river are stored in Wappapello Lake and released at rates which reduce flooding the lower subbasin. The USCOE Water Control Release Schedule for Wappapello Dam is dictated by reservoir stage, time of year (expected precipitation), and downstream agricultural activities (MDC 1995). The maximum possible release through the dam is 10,000 cfs, which is authorized only if reservoir storage capacity is threatened. The normal maximum discharge is 7,000 cfs during January and February, which can cause some limited agricultural flooding downstream if Mingo Ditch and Dudley Main Ditch have significant discharges. During most of the agricultural year (April through November), the preferred maximum discharge through the dam will produce a controlled

maximum flow of 3,800 cfs at the Fisk, Missouri and St. Francis, Arkansas gage stations. The minimum authorized low flow discharge through Wappapello Dam is 40 cfs. However, recent low flow measurements have determined that the minimum discharge going through the dam is actually 60 cfs (USCOE Personal Communications).

Peak flows at the Fisk gage station, 23 river miles below the dam, seldom exceed the channel capacity of 8,090 cfs. At the St. Francis gage station, 54 river miles below the dam, peak winter flows average 14,700 cfs, frequently exceeding the channel capacity of 6,300 cfs. Overbank flows in this channelized reach of river, however, are contained within an extensive levee system. There is not enough watershed area between the dam and the Fisk gage to provide significant runoff. However, major storm events can produce additional runoff that causes some overbank flows near the St. Francis gage.

Every five years the dam is completely closed for safety inspection that requires a complete dewatering of the spillway, which usually takes 8 to 12 hours to complete. However, the USCOE pumps water from Wappapello Lake into the river to maintain base flows.

An instantaneous record of channel depth (gage height) can be accessed through a 24-hour microwave telephone service at the Fisk and St. Francis gage stations. During stable flows, mean daily discharge can be inferred from gage height and mean daily velocity can be inferred from discharge.

DAM AND HYDROPOWER INFLUENCES

Wappapello Dam was completed in 1941 and has a drainage area of 1,310 mi². Project parameters are listed in Table 3. Generating capacity is a 175 kw turbine that only provides power to the dam facilities. Increasing hydropower capacity is not economically feasible. The dam impedes the upstream movement of fishes.

A mainstem dam at DiSalvo Lake (at Bismarck Conservation Area), is 30 ft high and blocks all upstream movement of fishes. The concrete dam was built in 1944 by the Hanna Mining Company, and is in the fourth order section of the mainstem at RM 423.2. The lake is 210 acres and floods 1.8 miles of St. Francis River channel.

There are four concrete dams located on mainstem tributaries in the upper subbasin that can block the upstream movement of fishes. Fredericktown Lake (municipal) is on the Little St. Francis River (5°) at RM 17.4; Killarney Lake (private) is on Stouts Creek (5°) at RM 4.8; Crane Lake (U. S. Forest Service, USFS) is on Crane Pond Creek (4°) at RM 13.2; and, Iron Mountain Lake (municipal) is on Indian Creek (4°) at RM 4.1. The impoundments are approximately 100 acres each and have extremely high watershed:lake area ratios. The dams have been in place for at least 40 years, and all have some draw-down capabilities. Killarney Lake was completely drained down to the old river channel in 1994 for dam repairs. A considerable amount of gravel was dredged from the basin during the draw-down.

In the lower subbasin, no dams or water control structures exist on the mainstem of the St. Francis River, in Missouri. Mingo Ditch, the largest tributary to the lower river, has a low-head water control structure (United States Fish and Wildlife Service (USFWS) Mingo National Wildlife Refuge (NWR) spillway) that can impede or encourage the upstream movement of fishes, depending on spillway operation. High velocity currents through the spillway during spring runoff or planned draw-downs attract many species of fish that eventually migrate through the spillway and upstream into the 3,000-acre swamp/wetland/ditch system on the refuge. When the spillway is not releasing excess refuge water, the discharge in Mingo Ditch (5°) is reduced to intermittent flow for at least three miles below the control gates (RM 16.2).

Table 1. Gaging Stations in the St. Francis River basin, Missouri.

Site	Stream	Agency	Gage Number	Location
ACTIVE GAGES				
Roselle	Upper St. Francis River	USGS	07034000	Hwy. 72
Mill Creek	Upper St. Francis River	USGS	07035800	Hwy. E
Saco	Upper St. Francis River	USGS	07036100	Hwy. C
Patterson	Upper St. Francis River	USGS	07037500	Hwy. 34
Wappapello Lake	Upper St. Francis River	USGS	07039000	Wappapello Dam
Iron Bridge	Lower St. Francis River	USGS	07039500	Co. Rd.
Fisk	Lower St. Francis River	USCOE	07040000	Hwy. 60
Dekyns	Lower St. Francis River	USCOE		Hwy. 53
St. Francis	Lower St. Francis River	USCOE	07040100	Hwy. 62
Brown Ferry	Lower St. Francis River	USCOE		Hwy. C
Holly Island	Lower St. Francis River	USCOE		Hwy. 84/90
Hargrove	Lower St. Francis River	USCOE		Railroad Trestle
Hopkins	Lower St. Francis River	USCOE		Hwy. 25
Lake City	Lower St. Francis River	USCOE		Hwy. 18
Des Arc	Big Creek	USGS		Hwy. 143
Fredericktown	Little St. Francis River	USGS		Hwy. 72
INACTIVE GAGES				
Ironton	Brewers Creek	USGS		
Fredericktown	Barnes Creek	USGS		
Piedmont	Clark Creek	USGS		

Table 2. Streamflow data for the St. Francis River Basin (USFR= upper St. Francis River, BGCK=Big Creek, LTSF= Little St. Francis River, CLCK=Clark Creek) (MDNR, 1995)

Gage Location	Stream	Max. c.f.s.	Min. c.f.s.	50% Exceeds	90% Exceeds	7-Day Q2	7-Day Q10
Roselle	USFR	43000	0.8	82	6	1.2	0.1
Mill Creek	USFR	24200	1.7	181	15		
Saco	USFR	65800	5.1	264	29		
Patterson	USFR	155000	8.0	335	52	32	15
Des Arc	BGCK	16000	5.1	55	16	9.0	4.8
Fredericktown	LTSF	11200	0.6	36	2.6	0.4	0
Patterson	CLCK	15500				2.8	1.4

Table 3. Wappapello Lake project parameters.

Specification	Conservation Pool	Recreation Pool	Flood Pool	
Elevation (NGVD)	354.74	359.74	394.74	
Surface Area (Acres)	5,200	8,400	23,200	
Storage Capacity (Acre-Feet)	30,900	85,100	613,200	
Average Depth (Feet)		6.5		
Maximum Depth (Feet)	42	47	82	
Shoreline (Miles)		180		
Flooded Mainstem (Miles)	26	28	35	
Runoff Capacity (Inches)			8.8	